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(19) (CA) **CANADIAN PATENT** (12)

(54) LASER DEPOSITION OF METAL UPON TRANSPARENT MATERIALS

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Background of the Invention

Field of the Invention

The present invention relates to a method of selectively depositing metal or other materials upon a transparent or translucent substrate. More particularly, the invention relates to a method and apparatus adapted for utilizing a laser beam to selectively deposit metal upon transparent materials in desired patterns.

History of the Prior Art

Laser beams have been utilized in various applications as light sources, and as machining devices in connection with metal and/or softer materials. In particular, U. S. Patent No. 4,000,492 describes a laser machining system wherein a laser beam is utilized as a source of pulses of coherent radiation directed to form discrete holes in a metal material.

Other laser systems have been utilized in image recording techniques. For example, U. S. Patent No. 4,001,840 describes a digital laser used in recording and reading apparatus.

In addition to these diverse applications of laser technology U. S. Patent No. 3,560,258 to Brisman discloses a technique of depositing materials in patterns by use of laser radiation and IBM* Technical Disclosure Bulletin, Vol. 8, No. 2, July 1965 to Potts et al. discloses a technique of inducing evaporation of materials for deposition, utilizing a laser source.

The Potts device, in particular, contemplates a technique for forming interconnection patterns on a substrate by placing opposite the substrate a film of evaporizable materials disposed on a glass plate. A laser beam of energy scans the metallic film through the glass plate to selectively evaporate portions of the film which then deposit upon the semiconductor substrate in accordance with the desired pattern. The Brisman technique appears to be useful but it has certain limitations in manufacturing performance. For example, the thickness of the film must be carefully controlled in order to yield a desired thickness on the substrate, and the placement of the film with respect to the substrate is likewise critical. Since the film is not reuseable the method would be relatively expensive. Finally, the location of the deposited area on the substrate is difficult to control inasmuch as the film obscures the substrate and prevents any visual registration between the laser source and the substrate.

* Registered Trade Mark

Accordingly, a need exists in the prior art for a method of depositing material, selectively, upon a substrate utilizing a laser source in a precise and well defined fashion.

Summary of the Invention

The present invention contemplates a method and apparatus for selectively depositing metal or other materials upon a transparent substrate utilizing a laser source. More particularly, the invention contemplates depositing material in highly selective areas with a high degree of adhesion and uniformity.

The invention attains these results with an arrangement wherein a laser source is located on one side of a transparent or translucent substrate upon which metal is to be deposited, so that the laser beam can be directed through the substrate. A reservoir of metal is located on the opposite side of the substrate adjacent to the surface thereof. Deflection means are provided to selectively scan the laser beam at predetermined intensity levels over a desired pattern.

The scanned laser beam acts to heat and vaporize metal from the metal reservoir, which is then redeposited upon the adjacent surface of the glass substrate. It has been found that with transparent substrates, metal and particularly conductive metal can be redeposited upon one surface thereof using this method with a high degree of adhesion and uniformity. The method has particular utility with respect to the repair of masks utilized in semiconductor fabrication, for example.

Brief Description of the Drawings

The drawing is a schematic illustration of a laser beam arranged in conjunction with a transparent substrate and a metal reservoir to perform metal deposition.

Detailed Description of the Invention

Referring now to the drawing a preferred embodiment of the invention is described including a laser device. The laser device includes a source 12, a lens system 14 and deflection means 16 which are illustrated in schematic fashion. These elements are tended to represent conventional laser components which are commercially available. Substrate 18 comprises a transparent element upon which material is to be deposited from a material reservoir 20 also illustrated in the figure. In the preferred embodiment a solid state Nd^{3+}:YAG laser is utilized, although other laser sources could be utilized as well. It is contemplated that the laser indicated have a wavelength in the order of 1.06 microns, and it should be apparent that the laser wavelength would be matched to the transparency wavelength of substrate 18 illustrated in the figure.

In the embodiment illustrated substrate 18 is supported along its edges by a suitable frame 22 and metal reservoir 20 is supported upon a base 24. In the embodiment illustrated the spacing between the underside of substrate 18 and the top of reservoir 20 is very small, i.e., in the order of a few thousandths of an inch. It is possible, in an alternative mode, to support the substrate on the metal reservoir in direct contact therewith. Means can be provided to adjust

the spacing between substrate 18 and the top of reservoir 20, if desired. The spacing between the substrate and reservoir is significant but need not be varied during the deposition operations.

Reservoir 20 can be comprised of a slug of any metal suitable for vapor deposition. In particular, it has been found that copper, brass, chrome and aluminum are suitable for laser deposition. In the preferred embodiment it is envisioned that substrate 18 comprise a transparent substrate such as a substrate upon which conductive metal layers are to be deposited. For example, substrate 18 might comprise a plate glass substrate. It is also possible that substrate 18 could be a transparent or translucent substrate upon which decorative layers of non-conductive metal are to be deposited, if desired. It should be apparent that the light absorption characteristics of the given substrate material, as matched to the source frequency of the laser employed constitute the limiting factor on the substrate materials and deposition materials which can be utilized.

In practice the apparatus described is preferably utilized to form selective deposition of metallic material, such as copper, upon the lower edge of a plate glass substrate by scanning the laser beam, under the control of deflection means, along a desired preselected pattern. Since the laser is directed through the glass, registration with a desired pattern can be quite easily accomplished. The laser deflection means is adjusted to vaporize metal at a suitable rate and the vaporized metal redeposits upon the underside of the substrate, providing good adhesion to the glass substrate and excellent uniformity of thickness.

The parameters used in the process depend upon the type of positioning system utilized to orient the laser with respect to the substrate. It should be obvious that an X-Y positioning system for the substrate could be utilized as well, if desired. In addition, the type of laser can be varied depending upon the type of metal to be deposited and the transparent substrate material which it is desired to deposit the metal upon.

It should also be apparent that materials other than metal could be deposited, if desired. In particular, non-metallic materials that are susceptible of vaporization can be processed utilizing the described arrangement.

The present arrangement has particular utility for fabrication of metallic lands upon solid substrates and, therefore, is susceptible of fabricating conductors or resistors upon such substrates. In addition, the method described can be utilized in repairing metal masks such as chrome masks deposited upon glass.

The method described has advantages over the prior art in that it is extremely a simple way of fabricating metal lands having uniform thickness and good adhesion. The use of the laser beam through a transparent substrate provides good registration with simple orientation apparatus; and the use of a metal slug for a metal reservoir is preferable to the use of thin film in that the metal slug can be reused. Alternatively, the metal can be retained within a crucible and maintained slightly above its melting point whereby depressions are not formed in the reservoir surface and the reservoir can be used for essentially continuous processing.

The following example discloses a preferred method of practicing the invention;

Example I

Using a YAG laser with a wavelength of 1.06 microns a layer of copper was deposited upon plate glass. The instrument configuration was similar to that illustrated in the drawing with a quarter inch copper slug being oriented adjacent to a 1/16th inch substrate of plate glass. The laser was utilized at a pulse repetition rate of 3 kilohertz, an average power rating of 2 watts, and a scanning speed of 2 millimeters per second. The linewidth of deposited material using the above configuration was in the order of 10 mils or less and a layer of copper of uniform thickness and good adhesion was formed upon the plate glass.

JMT:adm

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of selectively depositing material upon a transparent substrate comprising the steps of placing the transparent substrate adjacent to a source of material to be deposited,

directing a beam of laser radiation through the transparent substrate to a surface of said source of material,

and selectively moving the laser beam whereby the material is evaporated and redeposited upon the substrate.

2. The method of claim 1 wherein said material is a conductive metal.

3. The method of claim 2 wherein said transparent substrate is glass and said metal is copper.

4. The method of claim 1 wherein said laser is scanned across the substrate at a speed of about 2 millimeters per second.

5. The method of claim 4 wherein said laser is powered at a level of about 2 watts, with a pulse repetition rate of about 3 kilohertz.